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Operation
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SHOT SMALL BOY

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PROJECT OFFICERS REPORT—PROJECT 2.13

DEVELOPMENT AND EVALUATION OF A FALLOUT COLLECTOR (U)

M. J. Schumchyk, Project Officer

Carl Crisco

U.S. Army Nuclear Defense Laboratory
Edgewood Arsenal, Maryland

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DEPARTMENT OF DEFENSE
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ABSTRACT

The objective of Project 2.13 was to develop and evaluate a new fallout collector. This project participated in Operation Sunbeam, Shot Small Boy. Fallout collectors were installed adjacent to Project 2.9 manned instrument stations at 7,200, 15,600, and 28,000 feet in the expected downwind direction from ground zero. The principal areas for which data were obtained were (1) design, procurement, and fabrication of fallout collectors; (2) field operational performance of the instruments; and (3) analysis of fallout samples. A discussion of the data obtained is presented. From a mechanical and operational analysis, it was concluded that the fallout collector evaluated was satisfactory for use on future fallout projects at Nevada Test Site (NTS). However, sample analysis data obtained were insufficient for final evaluation of collector sampling efficiency.

PREFACE

References are exclud^d in this report since the subject matter, fallout collectors, is documented extensively in many weapon-test reports. A list of these reports may be found in the USAEC TID-9000 publications, "Abstracts of Weapon-Test Reports," under the subject matter of "Nuclear Radiation" and "Radiation Instruments".

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CHAPTER I

INTRODUCTION

1.1 OBJECTIVE

The objective of Project 2.13 was to develop and to evaluate a new fallout collector.

1.2 BACKGROUND

In the study of the effects of nuclear weapons, knowledge of the residual contamination resulting from nuclear detonations is required to effectively exploit their offensive use as well as to prepare necessary countermeasures for defense against them. Data on activity, particle size, weight, time of arrival, and time of cessation of fallout are required. To evaluate the fallout deposition from a nuclear detonation, it is necessary to collect a representative sample of the fallout material at several points of interest. Therefore, fallout particles from previous detonations have been collected and extensively studied. In most cases, however, the limited results obtained from these studies are peculiar to the design and application of the various instruments employed to collect the samples.

Data on particles collected in fallout collectors of variable design and reliability were difficult to correlate. The various designs of fallout collectors used at previous nuclear-effect tests have ranged from sophisticated to simple devices. They have included a remotely operated device to obtain small samples over a series of time increments, and the common bucket to obtain large integrated samples. The description and evaluation of these fallout collectors have been reported in previous weapon-test reports. Analysis of data in these reports indicates that some of the more direct design characteristics that have affected fallout collection are (1) area of collection-tray opening, (2) height of collection tray above ground, (3) protection of collected sample, and (4) recovery of sample. Other design characteristics pertaining to fabrication, installation, and field operation have indirectly affected the collection of a representative sample.

To facilitate obtaining necessary data on residual contamination from a nuclear detonation, a new fallout collector was designed and evaluated for use at future tests.

1.3 THEORY

Whenever a nuclear detonation is planned and the possibility of significant fallout exists, instruments to collect fallout are in great demand in order to cover the large ground areas for which fallout documentation is necessary. Usually these instruments are required in large numbers and **must** be fabricated in a relatively short delivery time. Therefore, a simple and inexpensive fallout collector was designed that can be mass-produced. It can be used as a single unit for total collection or in combinations to permit intermittent collections.

In order to obtain design and operational performance data on the new collectors, they were placed alongside similar types of collectors at Projects 2.9 and 2.11 stations. Fallout samples collected were analyzed and compared with results from other types of collectors in order to determine what degree of fallout representation was obtained.

CHAPTER 2

PROCEDURE

2.1 SHOT PARTICIPATION

Project 2.13 participated in Shot Small Boy. In order to fulfill the objective of this project, it was essential that the shot take place when wind conditions were such that fallout occurred in the direction of the station locations. An early morning detonation time was requested.

2.2 INSTRUMENTATION

2.2.1 Fallout Collector. The fallout collector (Figures 2.1 and 2.2) was devised to collect a sample of fallout representative of 2 ft^2 of earth surface. The opening for fallout collection measured 14.25 by 20.25 inches. The collector, designed with an emphasis on ruggedness and simplicity of operation, was constructed of corrosion-resistant, off-the-shelf-type items. It could be carried by two men and was mounted on adjustable legs so that its top could be set 3 feet above the ground. The collector opened on command from an electrical signal and remained open until closed by a second command; it was sufficiently dust-tight to prevent contamination of the collected sample.

The collector tray (Figure 2.3) was constructed of stainless steel with round corners and polished on the inside to facilitate sample removal. To prevent particles from bouncing out during collection, clean venetian blind slats were placed in a semigrid pattern inside the tray (Figure 2.4). To minimize weight and battery requirements, solenoids and springs (Figure 2.5) were used, in lieu of motors and gears, for moving the tray cover. A dry alkaline-type battery source (12-volt dc) was used as a power source. The timer (Figure 2.6) was designed to provide electrical signals capable of opening and closing, in sequence, 5 devices for collection of successive samples from 2 to 60 minutes' duration each, and one device for the collection of a sample from 10 to 300 minutes' duration. Sampling intervals within 5 percent of the chosen time increment were obtained with this timer. A remotely actuated hardwire or radio-relay signal was used to actuate the timer. Fabrication drawings are presented in Appendix A.

2.2.2 Installation. The sampling program was designed to collect representative samples of fallout as a function of time of arrival at ground locations of 7,200, 15,600 and 28,000 feet downwind from the point of detonation (Figure 2.7). Two stations (Figure 2.8) were located at 7,200 feet for correlation of data collection and instrument performance. Each station (Figure 2.9) was instrumented with six fallout collectors, one of which was timed to span the entire expected period of fallout in order to collect a total fallout sample. The other five collectors at each station were exposed sequentially during the period from shot time to the estimated time of cessation of fallout in order to obtain incremental fallout samples. Each station received a minus-30-second signal, and after a preset delay to allow the blast wave to pass, the total collector and first interval collector opened, collected samples, and finally closed after the chosen time intervals had elapsed. Timing data for each station are presented in Table 2.1.

2.3 OPERATIONS

Instruments were received from the manufacturer on D-14 days. They were unpacked and inspected for operation and shipping damage. A number of defects were noted and are listed below:

Defect	Number
Covers did not seal trays	14
Tray or cover did not release	3
Tray or cover released on shock (3 inch drop)	5
Damaged (bent or broken parts)	3
Loose nuts, bolts, parts	3
Cable off pulley (spring drive)	1

The defects noted were corrected and the units were covered and sealed to keep dust out of the mechanisms. The collectors were set up with reasonable ease by two people. However, it was necessary to exercise considerable care in loading the instruments on the truck so that no damage would occur during transport into the field.

Installation of fallout collectors was completed in 3 days. One week before D-Day the protective covers were removed and the collectors were tested. All malfunctions were repaired in the field. On D-2 days, all units were inspected and operated again. It was noted that the internal parts of the collectors were coated with dust; the oiled bearings and surfaces had accumulated heavy layers of dust. However, all units operated and no dust was found in the collector trays. Instrument and timing signal checks were completed on D-1 day.

Reentry for the purpose of collecting samples began at H+5 hours on D-day (as soon after the cessation of fallout as radiological conditions permitted). Recovery of fallout samples was completed on D-day. Recovery of station equipment and rollup was completed on D+7 days.

TABLE 2.1 **TIMING DATA FOR FALLOUT COLLECTORS**

Timing signal received at -30 seconds at all stations

Station Number	Distance From GZ	Preset Delay	Interval Sampling Time	Total Sampling Time
	ft	minute	minute	minute
541.02	7,200	1	2	10
541.04	15,600	2.5	5	25
541.06	28,000	5	10	50

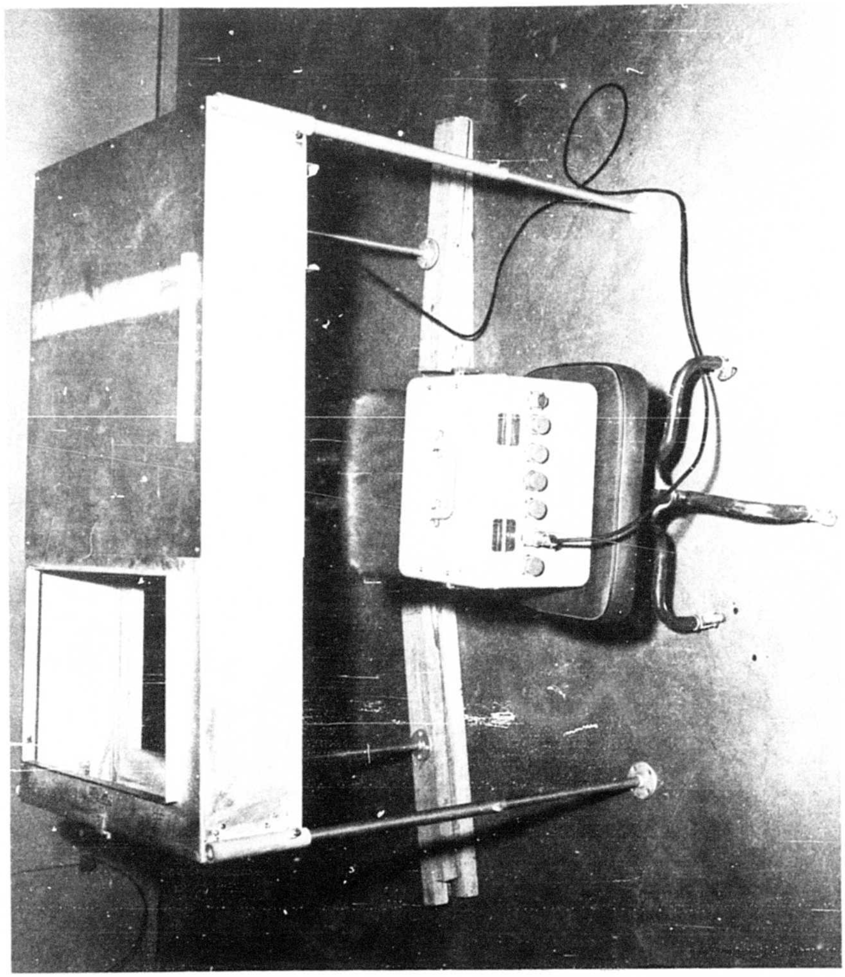

Figure 2.1 Fallout collector with tray covered, presampling position. (DASA 606-04-NTS-62)

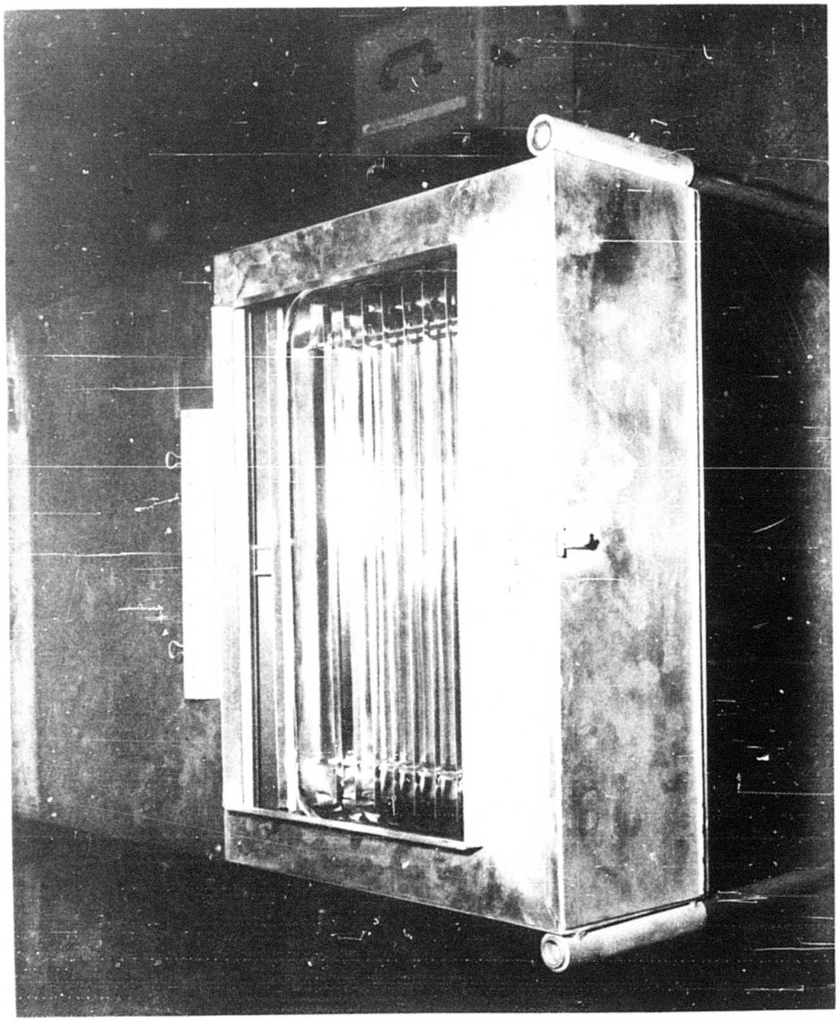

Figure 2.2 Fallout collector with tray open, sampling position. (DASA 606-07-NTS-62)

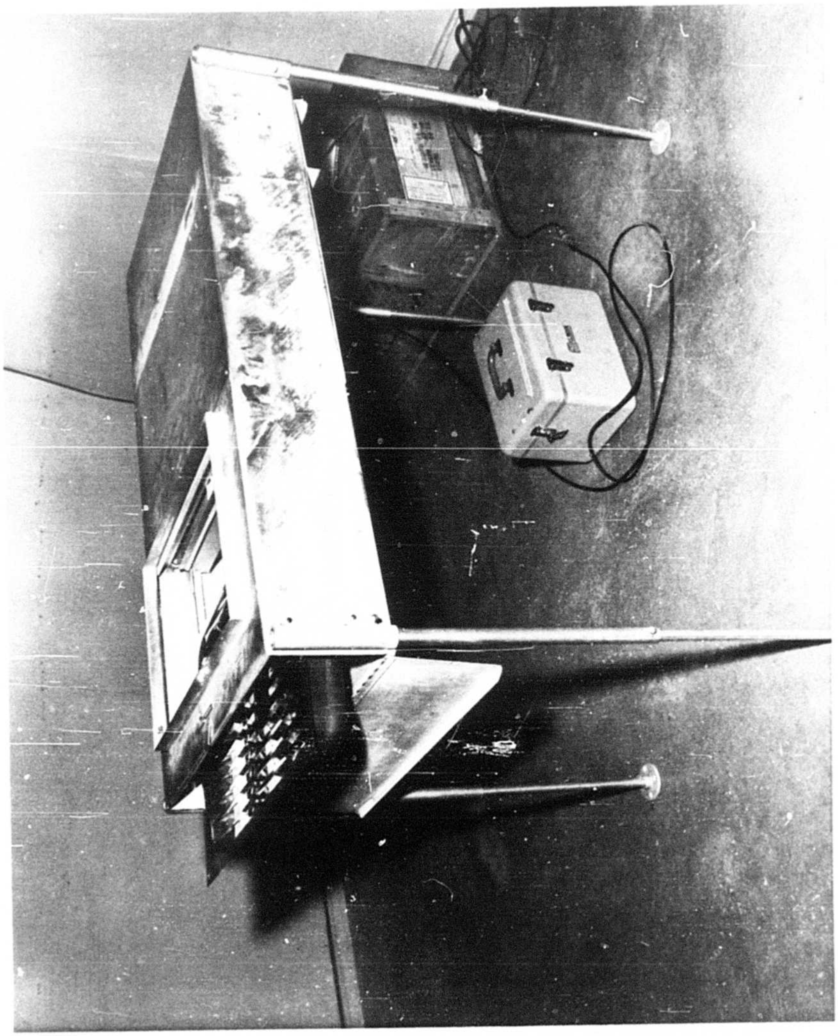

Figure 2.3 Collector tray, installation and recovery method. (DASA 606-08-NTS-62)

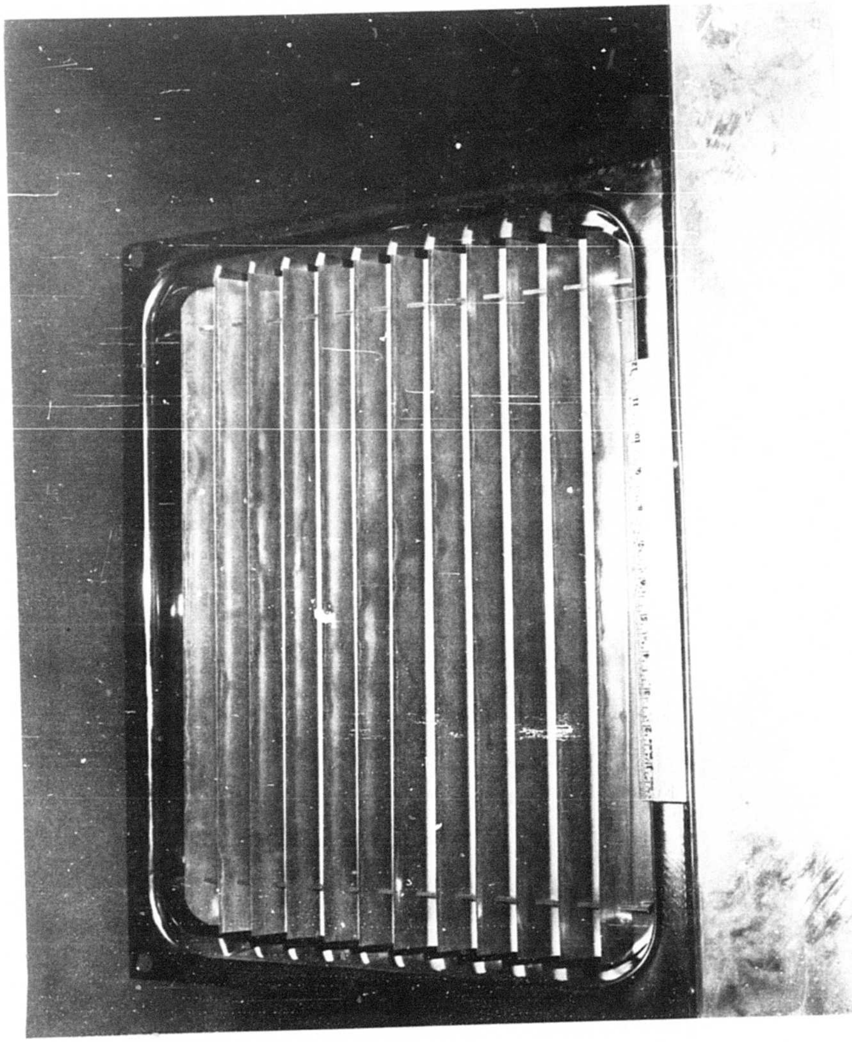

Figure 2.4 Collector tray with venetian blind slats. (DASA 606-06-NTS-62)

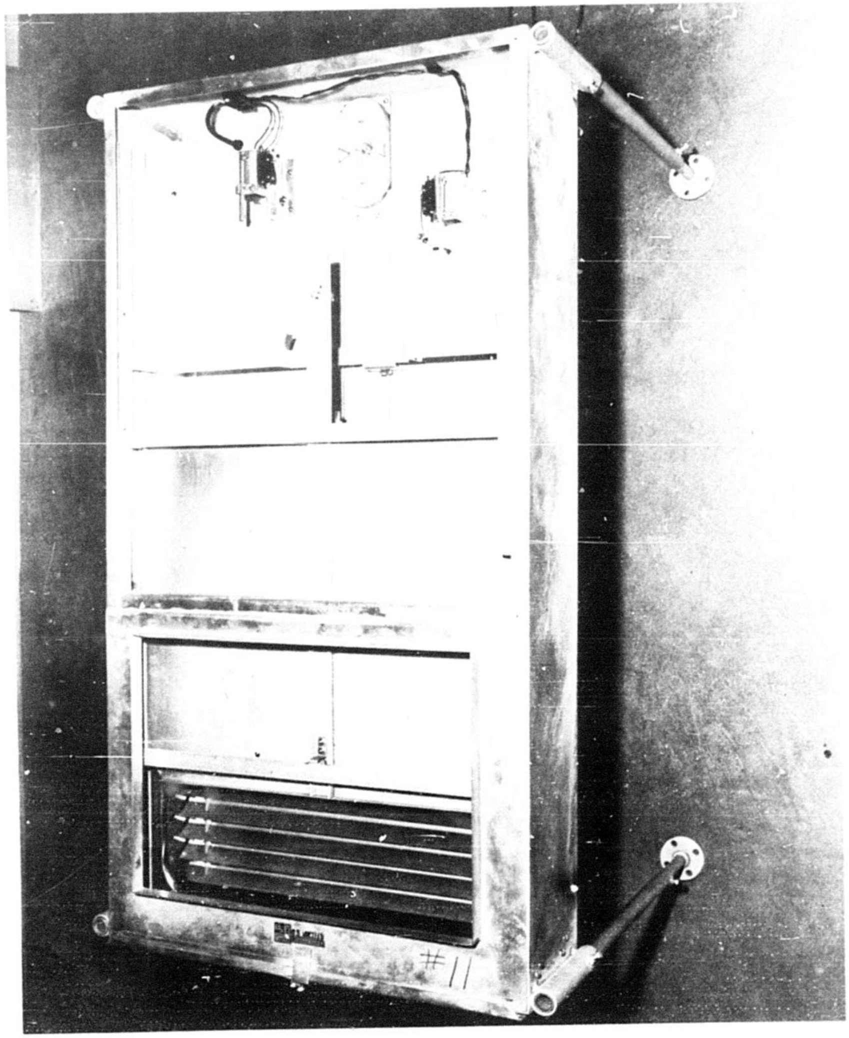

Figure 2.5 Solenoids and springs.
(DASA 606-09-NTS-62)

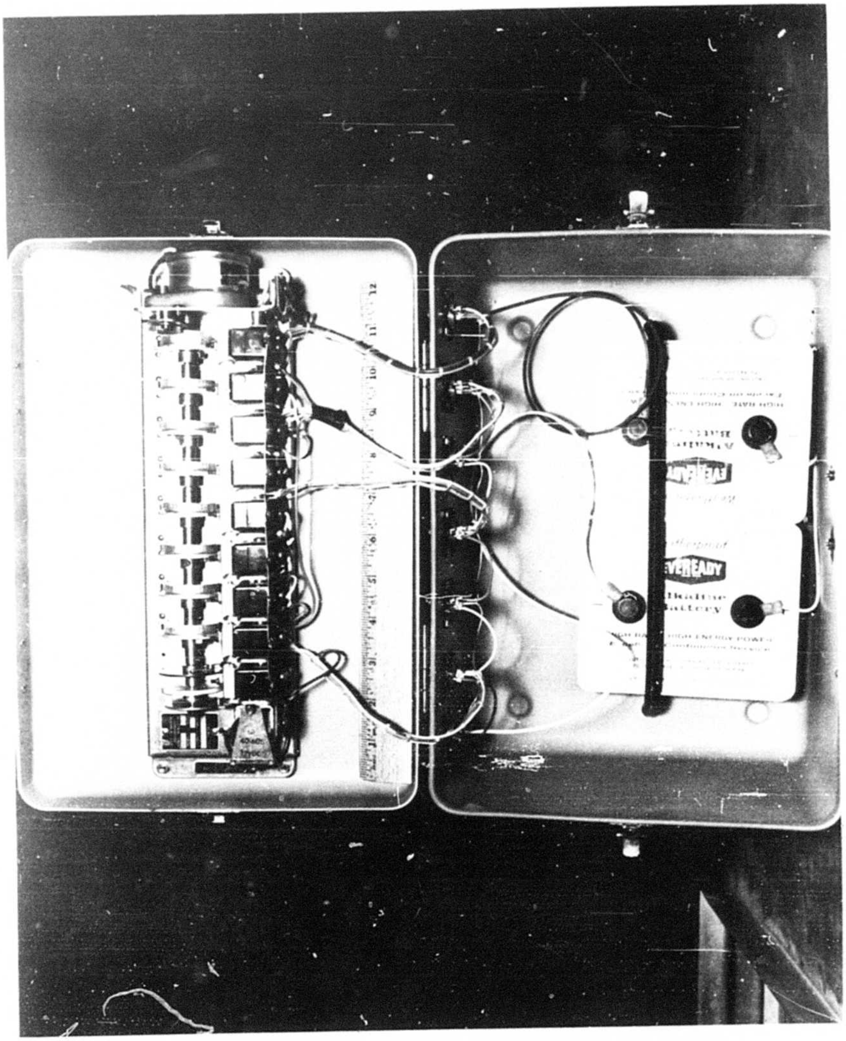

Figure 2.6 Timer. (DASA 606-05-NTS-62)

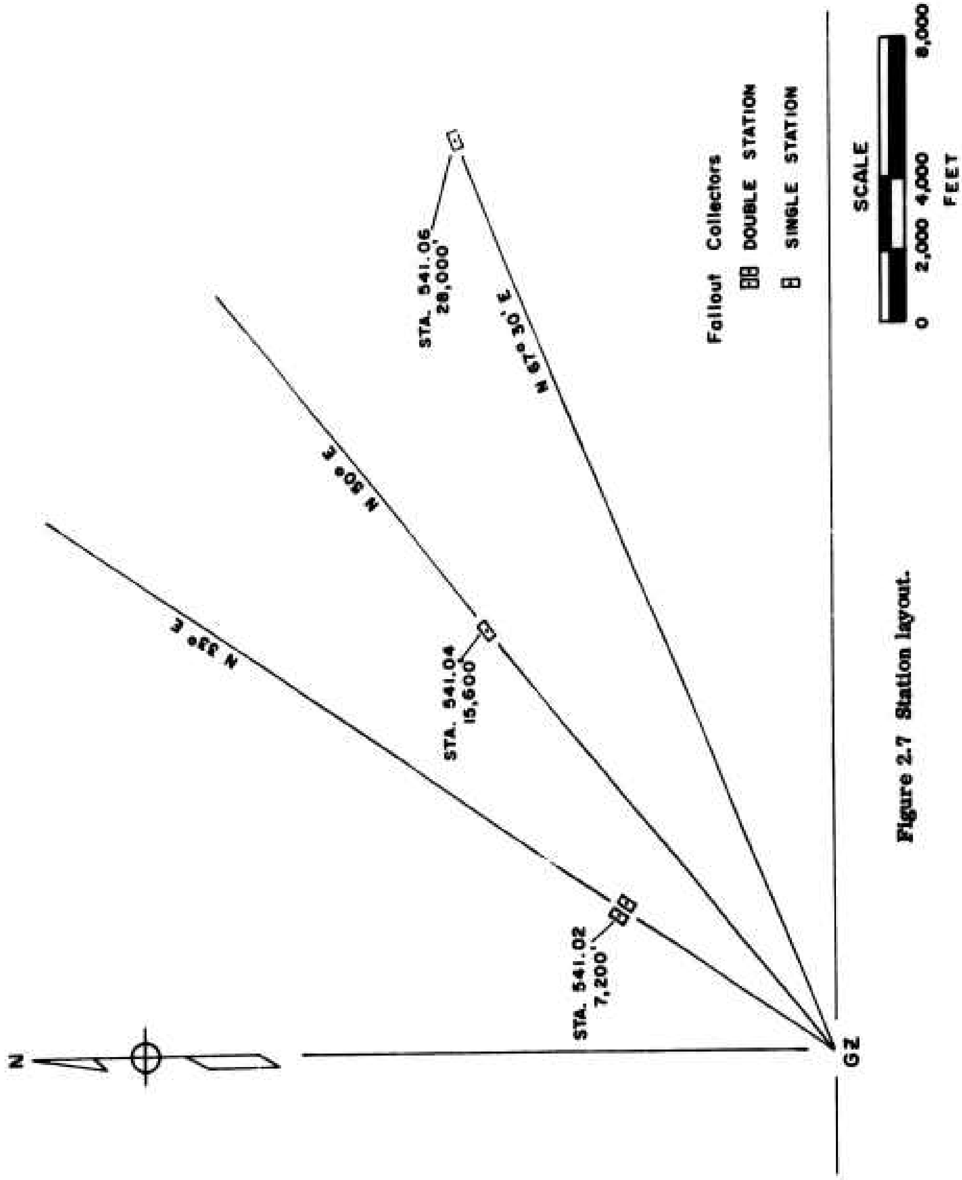

Figure 2.7 Station layout.

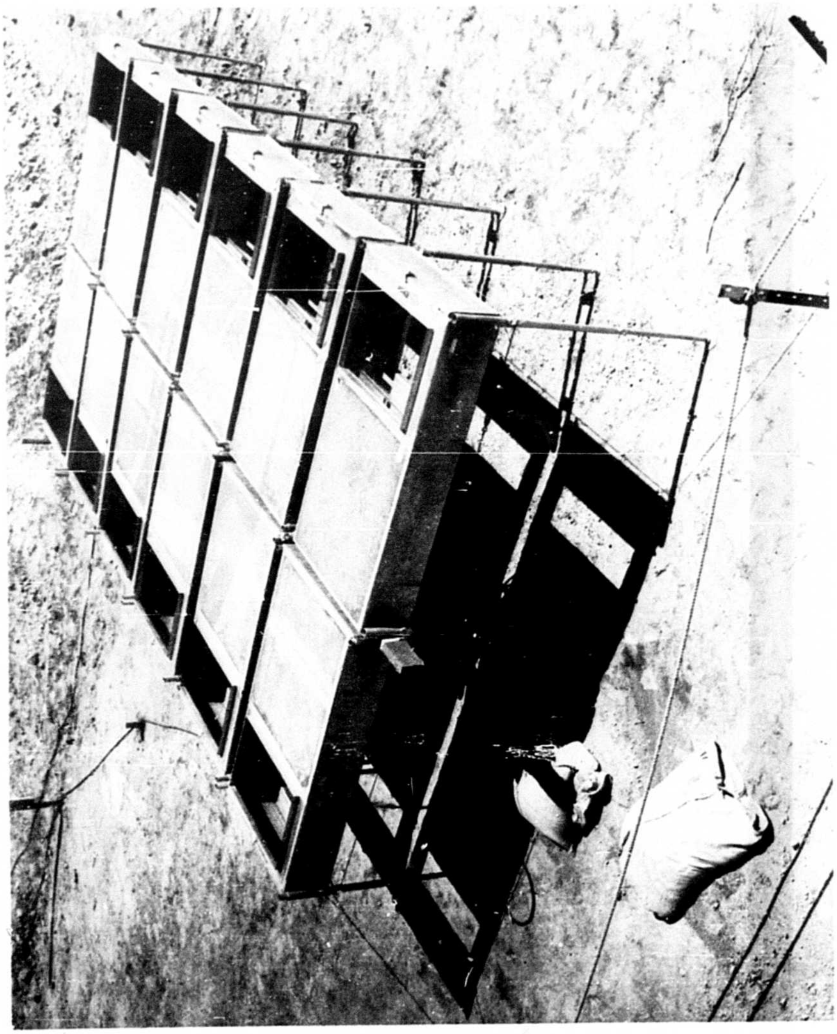

Figure 2.8 Double collector station at 7,200 feet from ground zero. (DASA 730-01-NTS-62)

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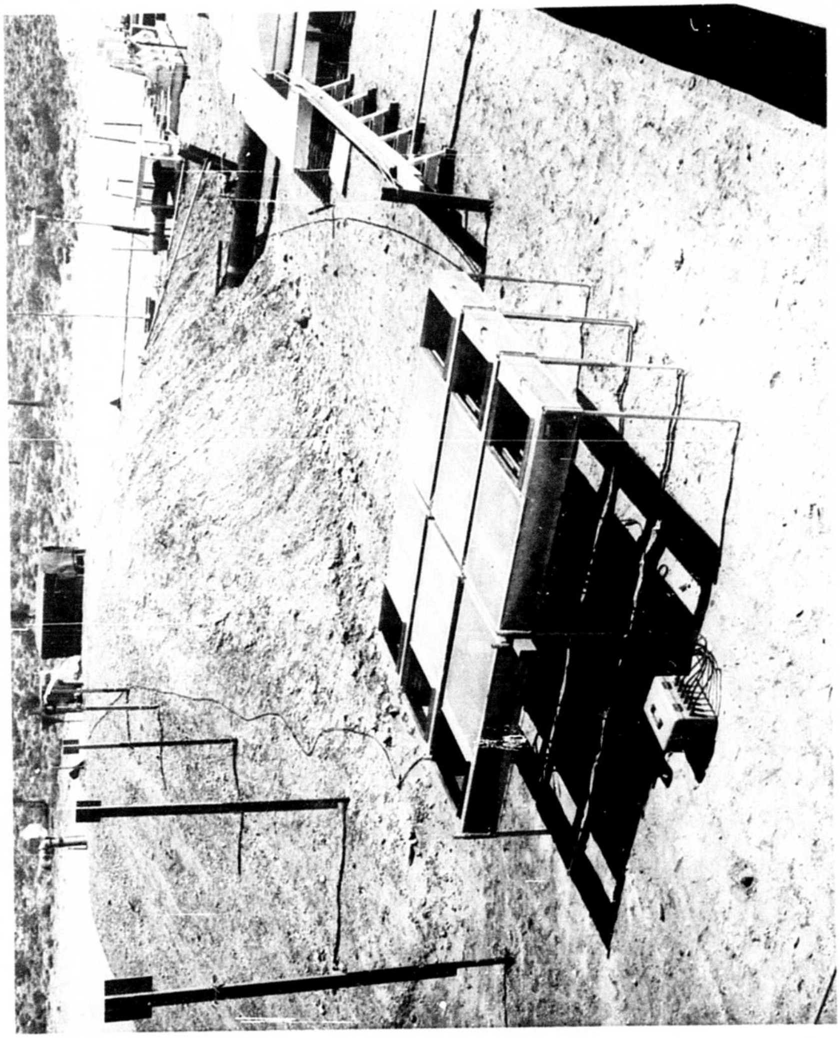


Figure 2.9 Single collector station at 15,600 feet from ground zero. (DASA 730-09-NTS-62)

CHAPTER 3

RESULTS

Experimental data, which can contribute to an improved instrument model, were obtained on the fallout collector. The principal areas for which data were obtained were (1) design, procurement, and fabrication; (2) operational performance; and (3) analysis of fallout samples.

The design and fabrication of the prototype fallout collector were completed within 30 days (370 man-hours) after the contract was placed. Approval of the prototype by the Project Officer was made 3 days later. Procurement of material and fabrication of 24 additional fallout collectors were completed within 45 days (940 man-hours after approval of the prototype). The intruments were shipped 83 days after the award of the contract and were received at the test site 2 days after shipment.

Field Operational performance of the fallout collectors was documented during installation, operational checks, and timing-signal dry runs. On shot day, 23 out of a total of 24 instruments operated. The one unit which did not operate was located at the close-in station (541.02) Also, at the close-in station, six covers did not close completely (less

2 to 3 inches). All but one of these covers (over collector and tray opening) faced ground zero and the prevailing winds. A heavy layer of dust accumulated on the ball bearings, thus restricting the cover movement. Timers, power supplies, and all supporting equipment functioned properly. There was no evidence of corrosion on any of the equipment.

Station 541.06 was in a fallout area (1.5 r/hr at H+5 hours). Collected samples from this station read approximately 150 mr/hr on the surface of the recovery box (2 ft^3). All recovered samples were delivered to Project 2.9 at the test site to be counted with an ion-chamber detector for gamma activity, and to obtain the weight of the collected samples. The results of the measurements on samples from Station 541.06 are shown in Table 3.1. The sample numbers S5-1 through S5-5 represent the sampling intervals. Sample S5-T is a total sample. The gamma activity of each weighed sample is the difference between Columns 4 and 5 in Table 3.1. Sample age at counting time was 13.0 days. Corrections for background, which averaged 442 counts/min, have been made in the figures. The 100-microgram radium standard read 32,600 counts/min for geometry conditions which were identical to sample geometry conditions. The other stations at which equipment was placed did not receive sufficient fallout to permit meaningful measurements to be made.

Analysis of the fallout sample data in Table 3.1 yields the following information for Station 541.06 (28,000 feet from ground zero):

1. Total gamma activity per unit area, 29,097 counts/min/ft^2

2. Largest interval activity per unit area, fourth interval, 25,995 counts/min/ft^2

3. Total mass in total collector, 0.1263 grams

4. Sum of mass in intervals, 0.1311 grams

5. Total gamma activity in total collector, 58,193 counts/min

6. Sum of gamma activity in intervals, 70,693 counts/min

7. Time of arrival of fallout, 25 to 35 minutes after zero time

8. Cessation of fallout, 35 to 45 minutes after zero time

Data collected by U. S. Naval Radiological Defense Laboratory under Small Boy Project 2.9 that pertain to gamma activity and mass of debris at Station 541.06 are shown in Table 3.2. Only that portion of the data pertinent to Project 2.13 evaluation is included.

TABLE 3.1 GAMMA ACTIVITY AND WEIGHT OF SAMPLES COLLECTED BY PROJECT 2.13 AT STATION 541.06

Sample Number	Sampling Period After Zero Time	Activity at D+13 Days Collector & Sample	Activity at D+13 Days Empty Collector	Weight Recovered
	minutes	counts/min	counts/min	gram
S5-1	4.5-14.5	597	368	Nil
S5-2	14.5-24.5	715	338	Nil
S5-3	24.5-34.5	13,802	743	0.0301
S5-4	34.5-44.5	51,989	3,029	0.1010
S5-5	44.5-54.5	3,590	496	Nil
S5-T	4.5-54.5	58,193	2,565	0.1263

TABLE 3.2 GAMMA ACTIVITY AND GROSS MASS OF DEBRIS COLLECTED BY PROJECT 2.9 AT STATION 541.06

Sample Number	Sampling Period After Zero Time	Activity at 100 HR Collector & Sample	Activity at 100 HR Empty Collector	Weight Recovered
	minutes	counts/min	counts/min	gram
507 IC 1	5-32	310	1,218	0.2676
507 IC 2	32-42	425,256	18,229	0.3725
507 IC 3	42-54	97,831	10,437	0.0844
507 IC 4	54-64	1,149	2,228	0.0710

CHAPTER 4

DISCUSSION

Operational tests of the fallout collector were successful. However, evaluation of the instrument for collection of fallout samples was limited by the small number of stations. An analysis of design considerations, procurement, and fabrication of the instruments is presented in Appendix B. As a result of the operational tests, the following design changes have been suggested:

1. Dustproof the collector mechanisms by providing a sealed, hinged door between the tray storage position and the sampling position. This could be pushed open as the tray is released.

2. Investigate the availability of sealed bearings and slides for the tray and cover carriers.

3. Redesign the trigger release mechanism to provide more positive action. Design a double scissors-type catch, or other type mechanism that would provide precise positioning of the catch to the carrier.

4. Lengthen leg holders at the corners of the collector cases. This would allow easier handling and stacking and would

provide better protection during shipping.

5. Stiffen the door end of the collector case and the tray cover. These changes would maintain better adjustments of tray to cover to provide better sealing.

6. Provide set screw adjustments under trays for greater ease in positioning of seal.

7. Investigate the use of constant-force extension springs of the Negator (or equal) type in lieu of sash balances. These are available in a larger number of force increments, are inexpensive, and could probably eliminate the use of two counterbalancing springs on each carrier. Their availability was discovered too late for use on this project.

The fallout collectors, with the preceding modifications, can be constructed inexpensively with a minimum expenditure of time.

Actual unit cost of the instrument was $830.00 which included design engineering, fabrication of the prototype, administrative expenses, and a fixed-fee profit. With the completion of the prototype, the instrument can be manufactured for approximately $500 each. Incorporation of the above design changes will provide a collector that is reliable, rugged, and easily handled in the field. Such a collector could operate in an overpressure area of approximately 5 psi.

As shown by the data from sample Number S5-3 in Table 3.1, time of arrival of fallout at Station 541.06 was between 25 and 35 minutes after zero time. This compared favorably well with cloud arrival time of 28 minutes, which was calculated from test-site weather data. A cloud travel time of 10 knots was determined from an average of wind speeds at 5,000-feet-thick layers of atmosphere from the earth's surface to the top of the cloud.

Sample data obtained by Projects 2.13 and 2.9 fallout collectors are compared in Table 4.1. Activity data from Project 2.13, which were measured on D+13 days, were calculated back to H+100 hours. This was done by multiplying the activity at D+13 days by the relative count ratio (4.17) obtained from the composite decay curve supplied by Project 2.9. The relative count at 100 hours was 10 and on D+13 days it was 2.4. The specific activity data indicate an order-of-magnitude correlation between instruments; however, the data obtained were insufficient for detailed evaluation.

TABLE 4.1 COMPARISON OF SAMPLE DATA, PROJECTS 2.13 AND 2.9

Gamma activity at 100 hours.

Sample Number	Sampling Period After Zero Time	Activity Concentration	Mass Concentration	Specific Activity
	minutes	counts/min/ft^3	gm/ft^3	counts/min/gm
Project 2.13:				
S5-1	4.5-14.5	1,240	Nil	-
S5-2	14.5-24.5	1,490	Nil	-
S5-3	24.5-34.5	28,600	0.0151	0.1895×10^7
S5-4	34.5-44.5	108,000	0.0505	0.2140×10^7
S5-5	44.5-54.5	7,780	Nil	-
Project 2.9:				
507 IC 1	5-32	77	0.0669	0.1157×10^4
507 IC 2	32-42	106,314	0.0931	0.1142×10^7
507 IC 3	42-54	24,458	0.0211	0.1159×10^7

CHAPTER 5

CONCLUSIONS

1. From a mechanical and operational analysis, it was concluded that the fallout collector evaluated by this project was satisfactory for use on future fallout projects at NTS. However, sample analysis data obtained were insufficient for evaluation of collector sampling efficiency.

2. Suggested modifications to the fallout collector are listed in Chapter 4.

APPENDIX A

FABRICATION DETAILS AND SPECIFICATIONS

Table A.1 and Figures A.1 through A.13 present fabrication details and specifications for the fallout collector. Many of the parts are off-the-shelf type items purchased from distributors located in the same area as the contractor. Only one item, the timer, was purchased from a distributor located outside the contractor's state.

TABLE A.1 PURCHASED PARTS LIST

PURCH. PARTS:

REQ'D PER ASSY	
ONE	#4½ TWIN ACME BALANCE
ONE	#5-6 TWIN ACME BALANCE
TWO	· PULLEYS
TWO	B-2000-27 TRACKS - SLIDES - WASHINGTON STEEL PROD.
TWO	TYPE A-A · SWITCH · - MAXSON ELECTRONICS CORP
TWO	#11 6V DC SOLENOIDS - GUARDIAN CONTROLS
ONE	SHEET METAL DOOR LATCH - SOUTHCO OR EQUIV
ONE	A-190-3 STAINLESS · FAN. ZIEGLER - HARRIS INSIDE DIMS. 21¾ × 15¾ × 3 DEEP

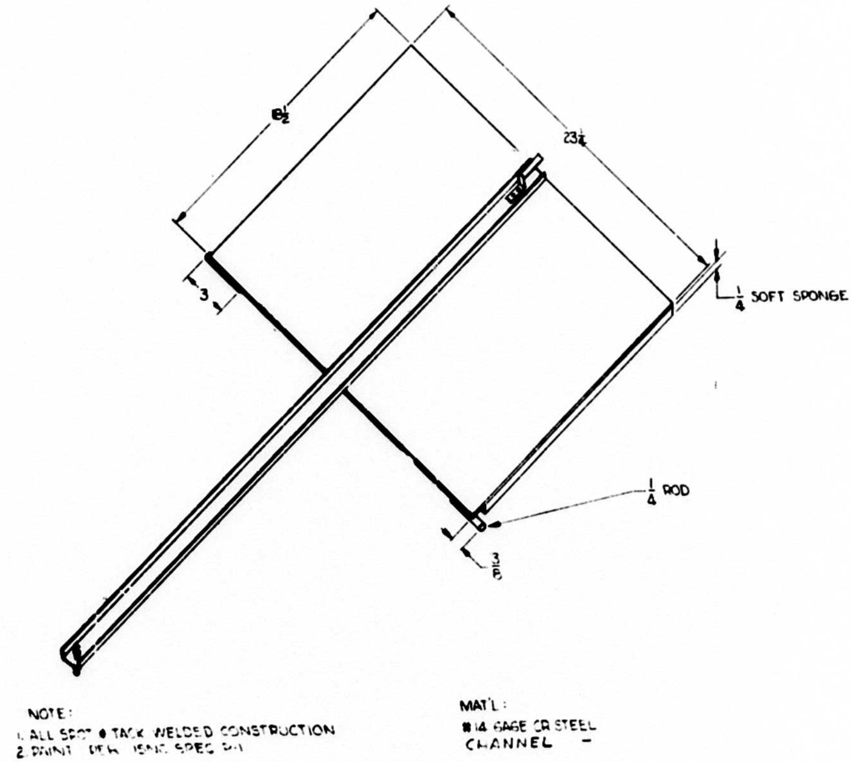


Figure A.1 Cover for collector louvers.

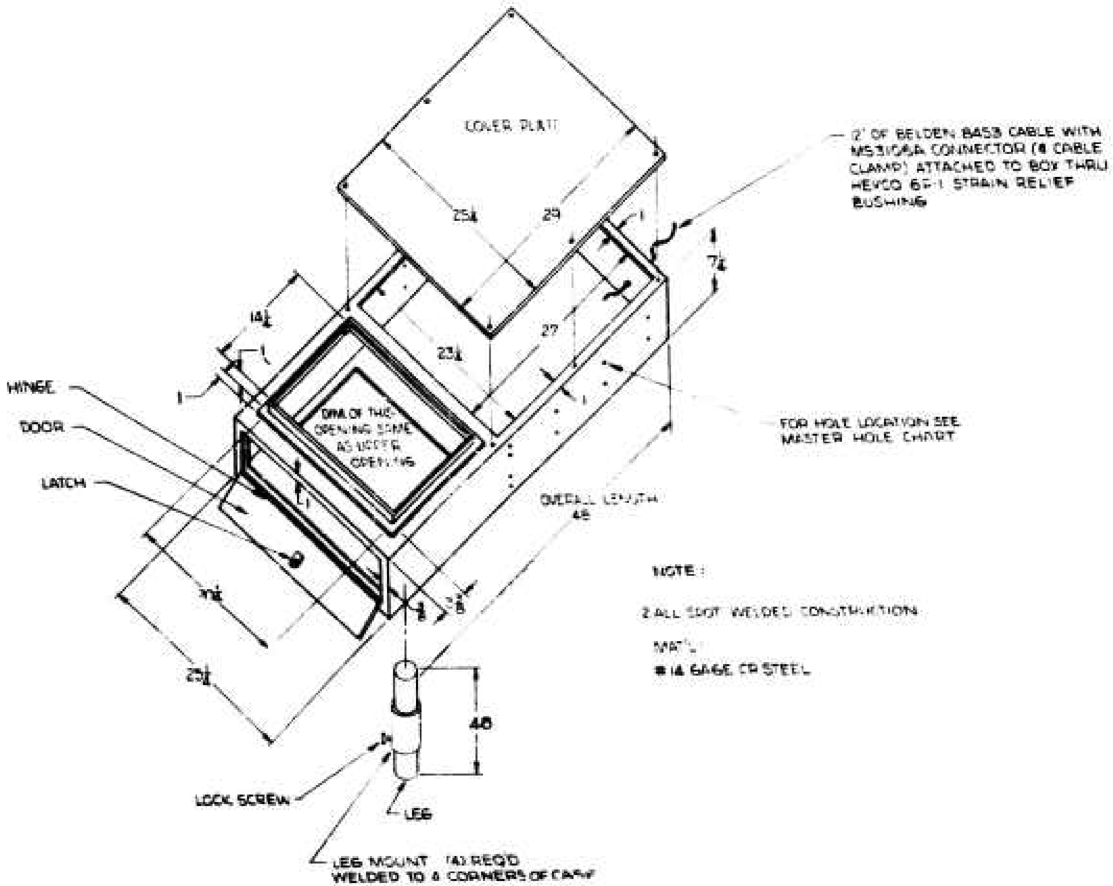


Figure A.2 Design for collector case.

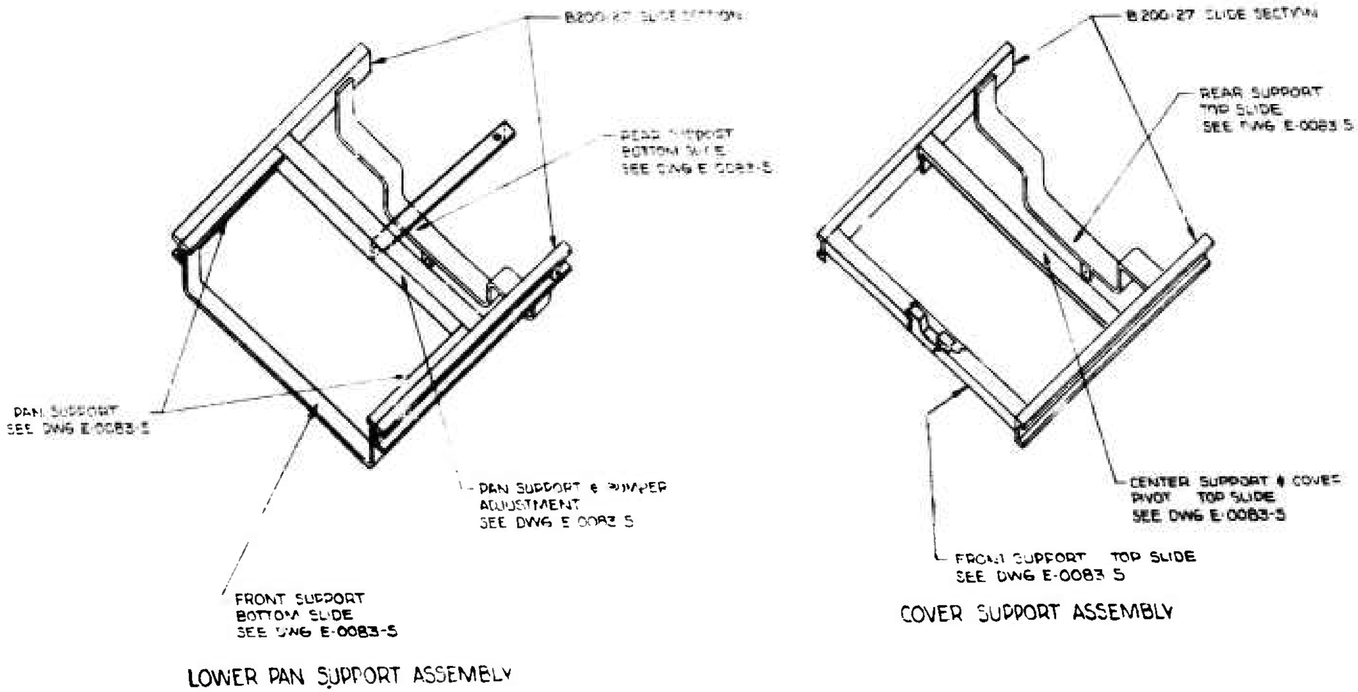


Figure A.3 Pan-cover support assembly.

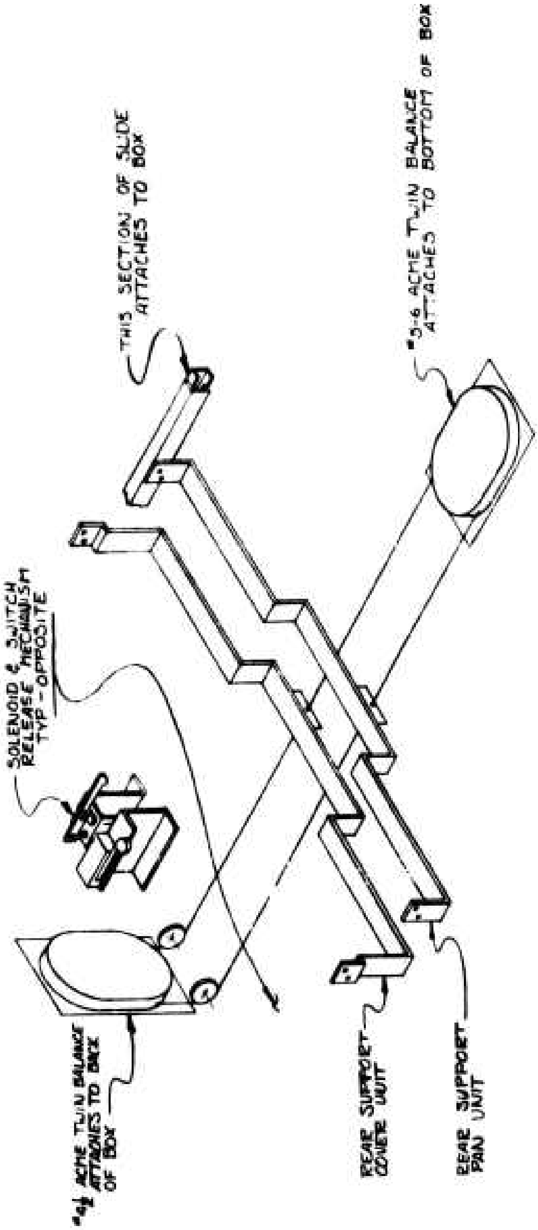


Figure A.4 Linkage diagram.

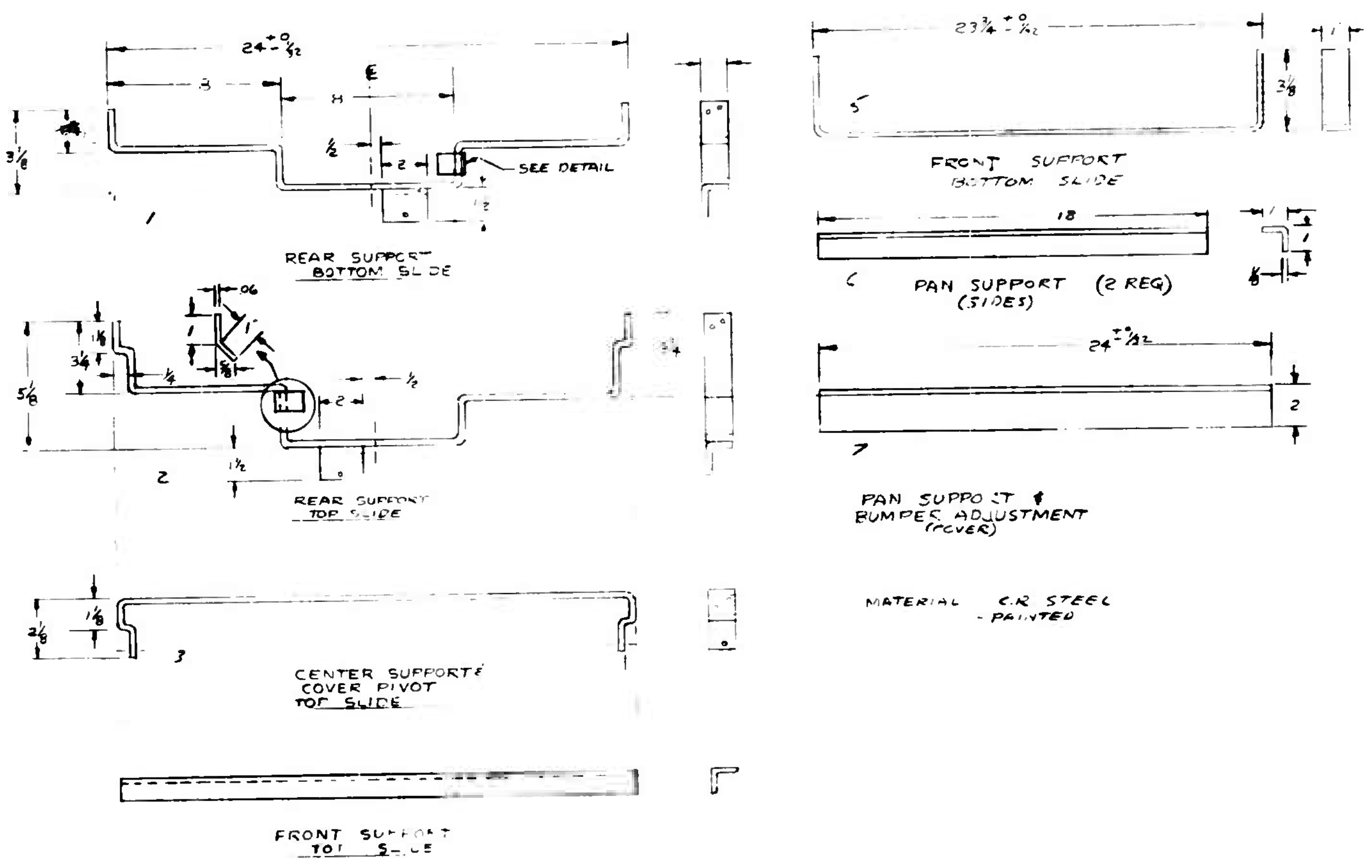
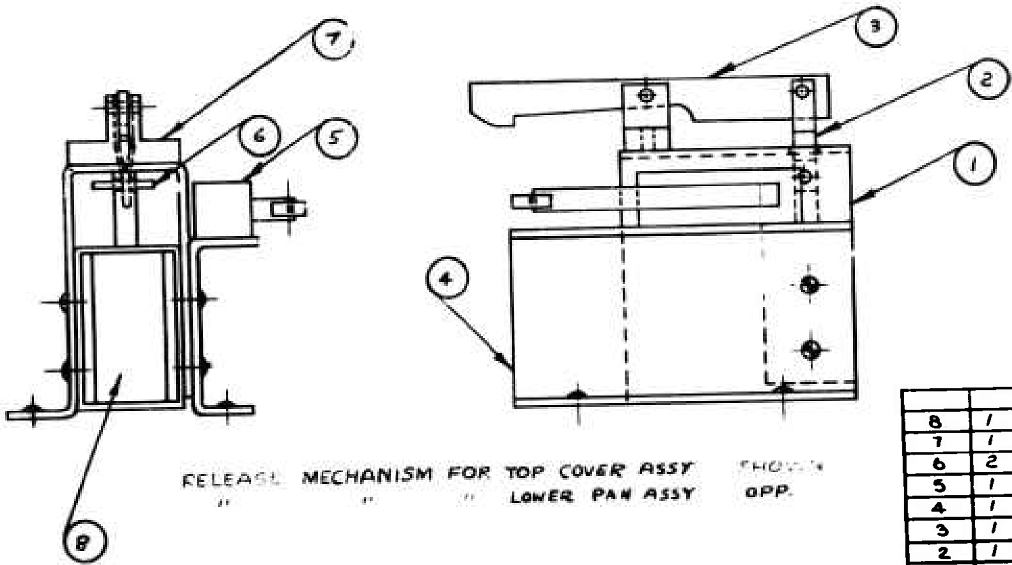


Figure A.5 Support details.



PART NO	REQD	MAT'L	DESCRIPTION
8	1		GUARDIAN-11-6 DC SOLENOID
7	1		E-0083-7
6	2	ALUM	PINS- 1/8 DIA CLEVIS PIN
5	1		UNIMAX SWITCH NO. AA
4	1	STEEL	#14 GAGE
3	1		E-0083-9
2	1		E-0083-8
1	1	STEEL	#14 GAGE

Figure A.6 Release mechanism support.

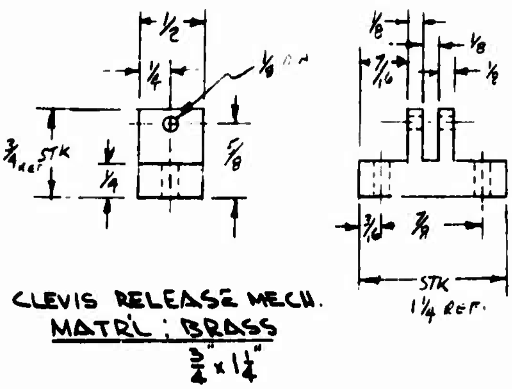


Figure A.7 Clevis release mechanism.

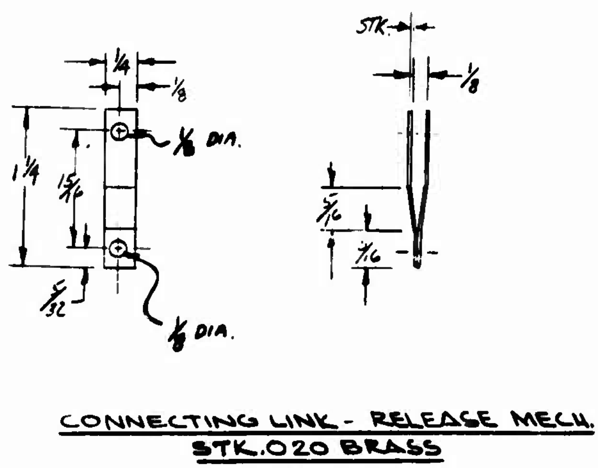


Figure A.8 Connecting link-release mechanism.

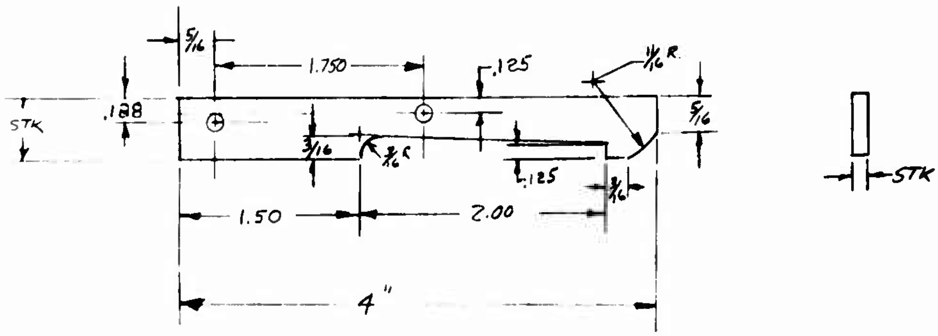
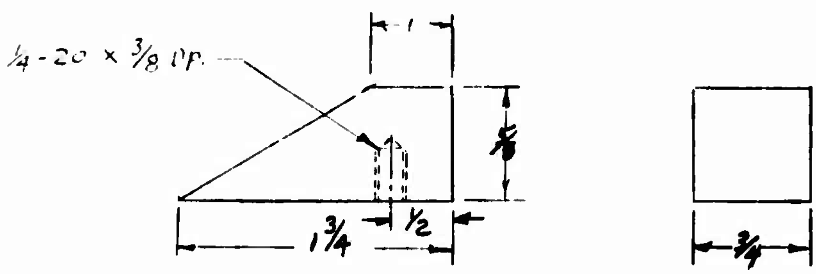
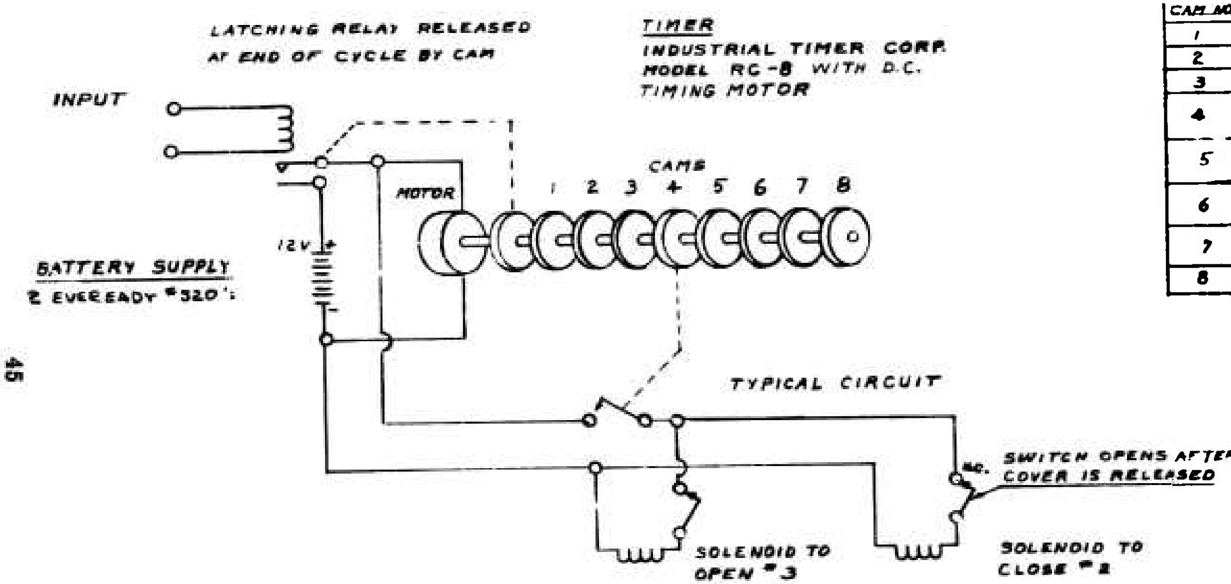


Figure A.9 Catch-release mechanism.



MATL. BRASS

Figure A.10 Wedge, pan slide assembly.



CAM NO.	OPERATION
1	OPEN #1
2	CLOSE #1
3	OPEN #2
4	CLOSE #2 OPEN #3
5	CLOSE #3 OPEN #4
6	CLOSE #4 OPEN #5
7	CLOSE #5 OPEN #6
8	CLOSE #6

Figure A.11 Timer schematic.

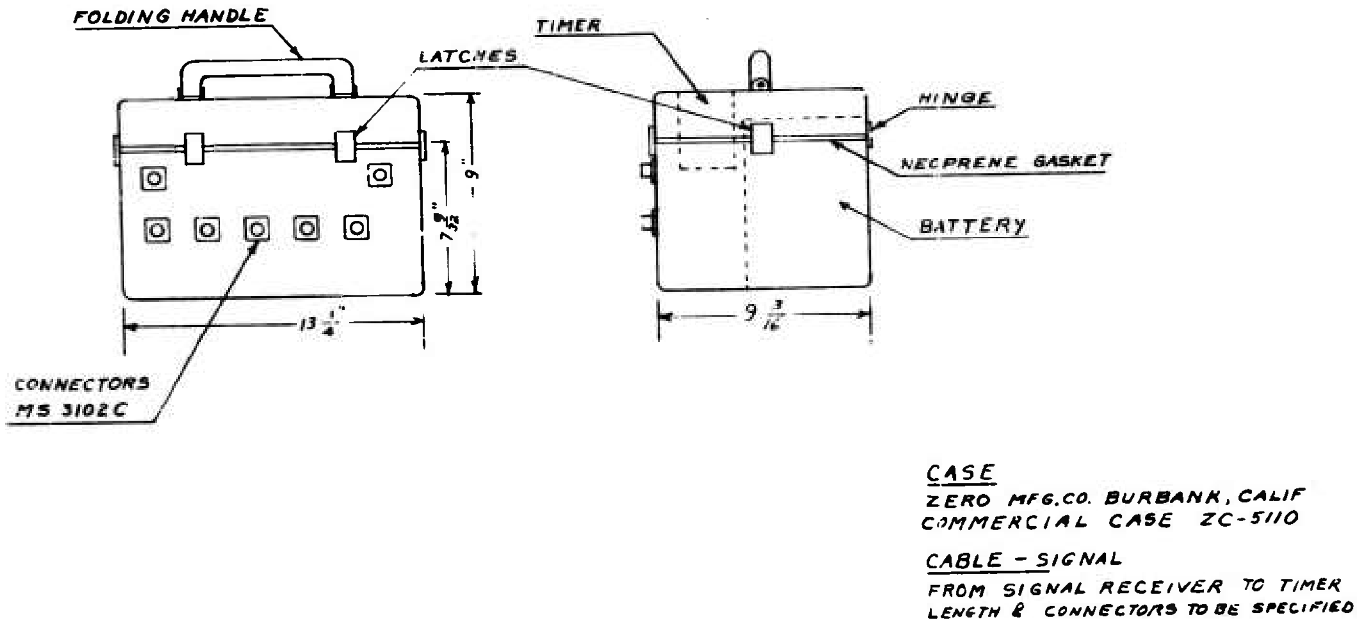


Figure A.12 Timer assembly.

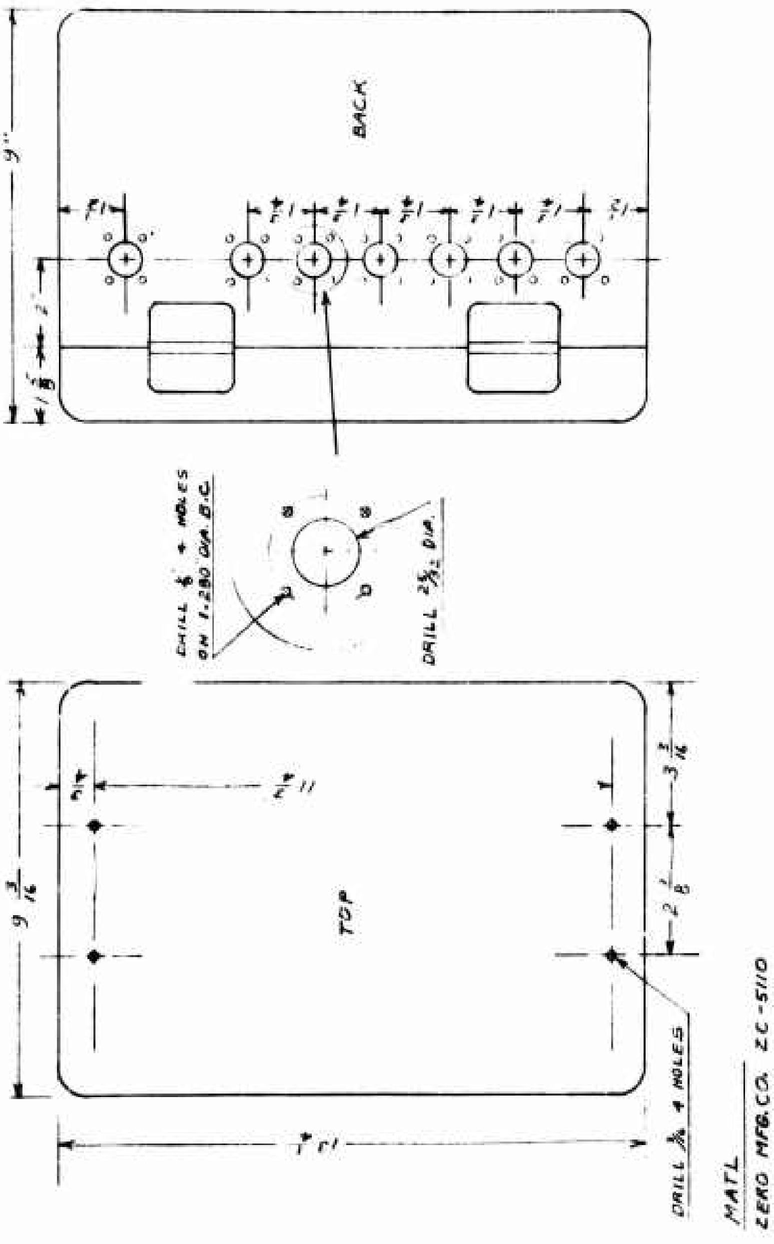


Figure A.13 Box, electrical.

APPENDIX B

DESIGN, PROCUREMENT, AND FABRICATION

B.1 DESIGN CONSIDERATIONS

B.1.1 Collectors. The basic concept of uncovering and recovering a tray in the field was considered from several approaches. Because the size of the opening immediately above the tray was limited to 2 ft^2, vertical movement of the cover with respect to the tray was excluded. Mounting a cover on a pivot was considered, but this approach required greater precision in fabrication than the design chosen. Several combinations of movement of covers or trays, or both, were considered. The one chosen afforded maximum simplicity because it required movement in only one direction, and it gave maximum protection from the elements by providing a semiprotected location for both cover and tray prior to the sampling period.

Specifications of the accepted design included a tray and cover (with foam plastic for sealing) mounted on carriers inside a rectangular metal case; a 2 ft^2 collection area in one end of the case; and the cover and tray in the presampling position at the other end of the case. On signal, the tray moved to the sampling position, and on the second signal, the cover moved into position to cover and seal the tray.

Several methods of driving the carriers were considered, i.e., geared motors, or motors with gear, roller chain, or cable drives.

All of these were discarded because of excessive power requirements and costly precision fabrication. Instead, a spring drive was chosen; the actual hardware consisted of sash balances. These were inexpensive, off-the-shelf items, and included corrosion-resistant spring housings and extension cables. The range of springs available was limited; two counterbalancing springs provided the optimum force, and thus, a differential force for each carrier system.

Carriers for trays and covers were fashioned from ball-bearing nylon wheels mounted on heavy-duty rolling drawer slides attached to the sides of the case. These were also inexpensive off-the-shelf items.

Release mechanisms for positioning the tray and cover on command were provided in the form of triggers operated by standard dc solenoids. No other concept appeared competitive with this type of mechanism.

Cadmium plating on steel was used to make the collectors corrosion-resistant. Aluminum was considered for construction of the case; this would provide a lighter unit, but would increase the cost of materials and fabrication by one-third. Adjustable legs at the four corners of the case were made from telescoping tubes.

B.1.2 Timers and Power Supply. The timers selected consisted of a series of individual cams mounted on a common shaft driven by a dc timing motor through a suitable gear train. The cams operated individual snap action switches and were adjustable on the shaft to less than 1 percent of the total time cycle. A total of 50 inexpensive, interchangeable, gear-reduction units provided total-time cycles from 40 minutes to 6 hours. Three such units were provided for each timer to meet the requirements of this project. Maximum timing precision was obtained by choosing the gear-reduction unit nearest the total-time cycle desired. Some consideration was given to a spring-driven timer (clock mechanism) that could be started by an electrical signal. However, no supplier for this type of timer could be found.

The electrical power supplies were established by the operating requirements of the collector solenoids, the timer motors, and the batteries available. The timer power requirements were for a constant voltage, moderate current (150 ma), 6-hour-maximum supply. The solenoids required a high current (3 amp) of short duration. Since two solenoids were actuated simultaneously, a 6-amp capability was required. The only dc timing motors available on short notice required 12 volts. A small, lead-acid type storage battery would be the best choice for meeting these requirements. However, there would be serious objections to such a battery when intended for field use, e.g. acid spillage, excessive size and weight, charging and recharging, etc. A primary cell of the alkaline type (Eveready No. 520) was found to be quite satisfactory. It could supply the high current for the solenoids and also had a high-power capacity in a small package at a moderate cost.

In order to limit battery drain from the solenoids, snap-action switches were mounted in the collectors to open the solenoid circuits after release of the tray or cover. If trays or covers did not release, the solenoid would remain energized until turned off by the timer cam. The batteries selected provided enough power to complete a 6-hour cycle in the event none of the pans or covers released.

Timers and batteries were mounted in a dust-tight metal case with connectors on each unit for the incoming signal and six outgoing signals to the collectors.

B.2 PROCUREMENT AND FABRICATION

The timers presented the only real procurement problem, the major difficulty being the dc timing motor. Six-volt motors (original specification) were not available; therefore, 12-volt motors were used. Only one vendor was located who could meet the delivery schedule, and he could not meet the schedule for the prototype.

Stainless steel trays were obtained from a sink manufacturer and were given a special polished finish. All other purchased parts were in stock. Fabrication of the collector cases, tray and cover carriers, and covers was subcontracted in order to expedite delivery. However, the subcontractor manufactured the collector parts only in small batches, and this resulted in a number of delays in getting the parts to the primary contractor's assembly plant.

B.3 MANUFACTURING PROOF TESTING

Collectors were tested for operation 25 times each without timers, but with the same power supply. They were also given a 3-inch drop test onto a concrete floor. Testing revealed the need for minor adjustments in trigger release mechanisms, and in positioning of trays and covers for proper sealing. All collectors were adjusted and retested.

Each timer was tested with an array of six collectors to insure proper power supply, proper sequencing, and timing accuracy. Tests indicated proper operation and timing accuracy within the prescribed limits. No environmental or corrosion testing was performed.

B.4 PACKAGING AND SHIPPING

Collectors were shipped, with legs removed, in stacks of five on wooden skids. Wooden bracing was used between the units and on the sides of the stack. Each stack was stabilized by clamping legs in the leg-support tubes at the corners. Each stack was enclosed with polyethylene, covered with corrugated cardboard, and banded to the skid.

Timers and auxiliary equipment (legs, cables, tray covers for use during sample pickup, etc.) were shipped in corrugated cardboard cartons. Batteries were removed from timer cases during shipment.

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